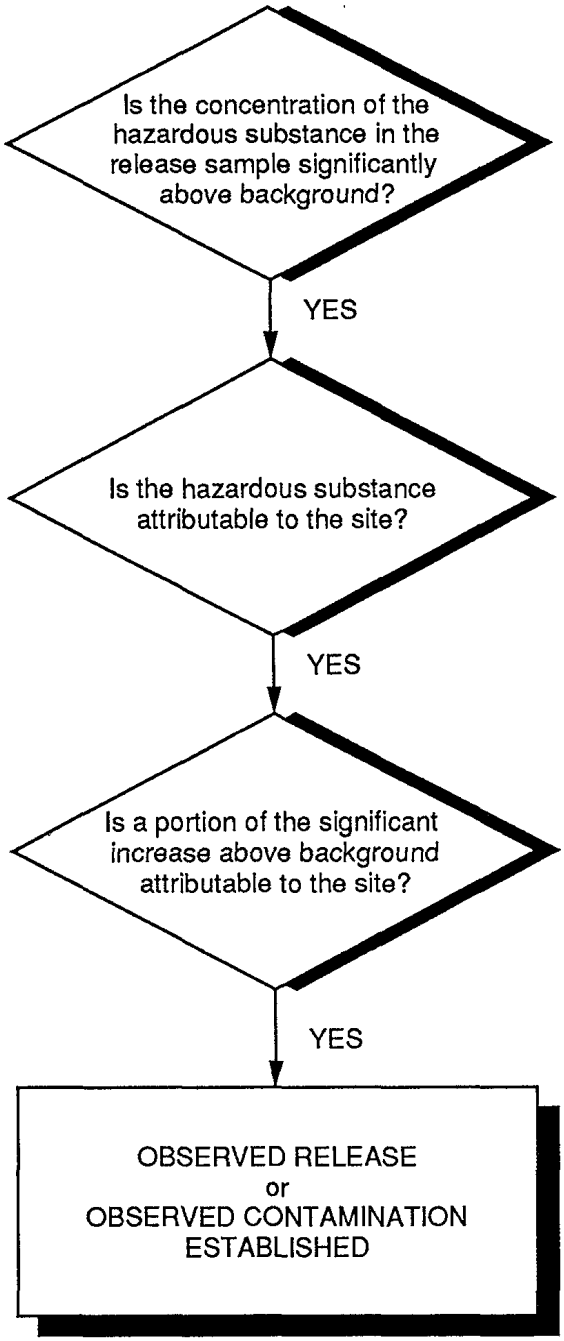
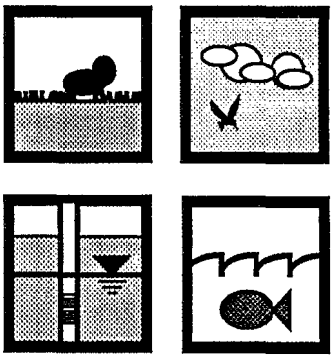
CHAPTER 5
OBSERVED RELEASE



SECTION 5.1
ESTABLISHING AN OBSERVED RELEASE AND OBSERVED CONTAMINATION



This section provides guidance on establishing an observed release in the ground water, surface water, and air migration pathways and on establishing observed contamination in the soil exposure pathway. Establishing an observed release (or observed contamination) is an important determinant of an HRS pathway score. If an observed release is established for a migration pathway (i.e., ground water, surface water, and air pathways), likelihood of release for that pathway is automatically assigned its maximum value of 550 points. Establishing observed contamination is a necessary condition for evaluating the soil exposure pathway; the pathway score is automatically assigned a 0 if observed contamination is not established. Establishing an observed release (or observed contamination) also is necessary for establishing actual contamination for targets.

An observed release can be established either by direct observation or by chemical analysis. Observed contamination (in the soil exposure pathway) can be established only by chemical analysis. Establishing an observed release by direct observation generally requires information on material containing a hazardous substance that has been placed into or has been seen entering the medium of concern and attribution of that substance to the site (see ***Highlight 5-1***). Establishing an observed release (or observed contamination) by chemical analysis generally requires attributing the hazardous substance to the site, and also requires determining background, demonstrating that the concentration of the hazardous substance in a release sample is significantly increased above background, and attributing some portion of the significant increase to the site.

RELEVANT HRS SECTIONS

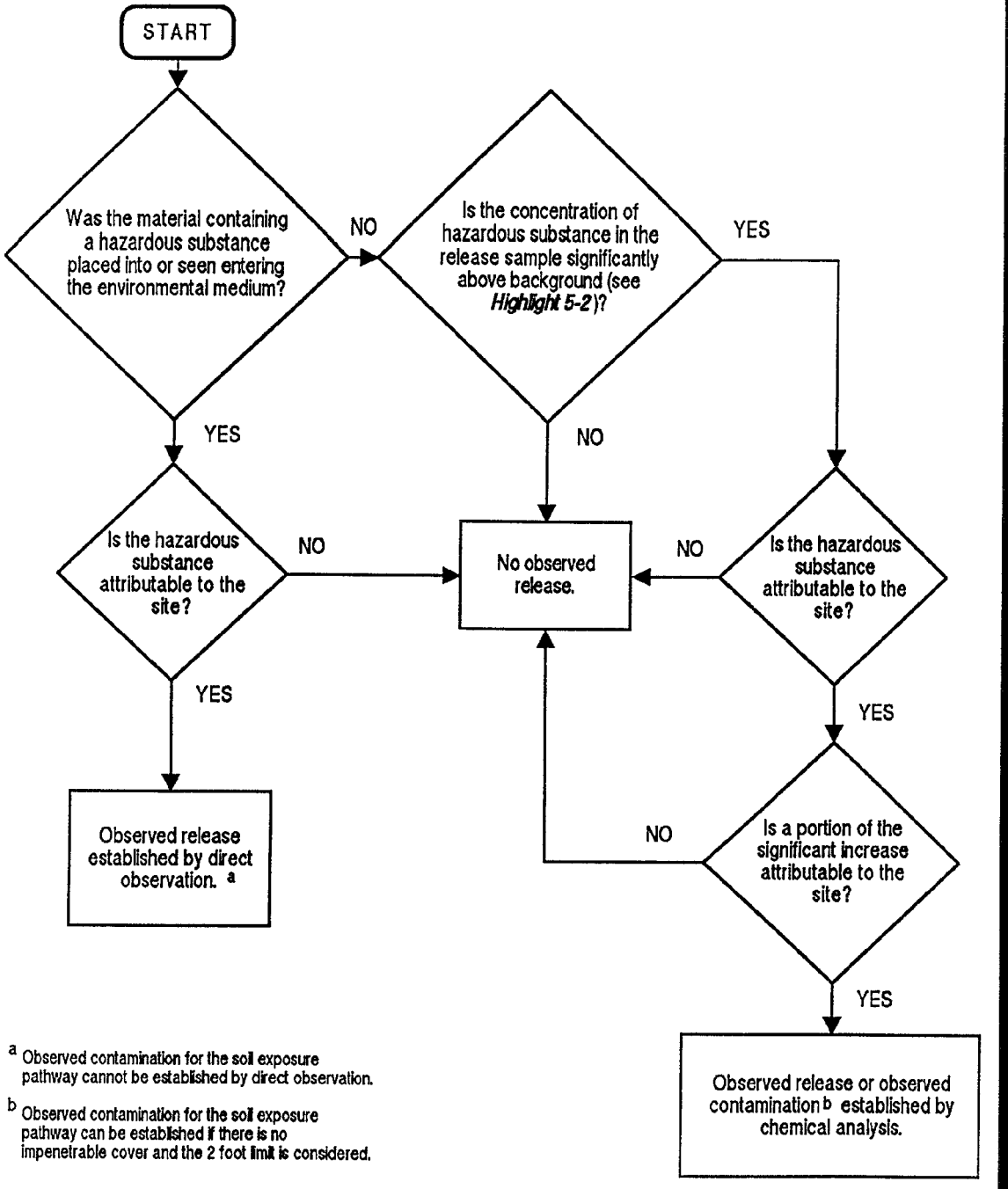
Section 2.3	Likelihood of release
Section 3.1.1	Observed release (ground water)
Section 4.1.2.1.1	Observed release (surface water)
Section 5.0.1	General considerations (soil exposure)
Section 6.1.1	Observed release (air)

DEFINITIONS

Attribution: The determination that a hazardous substance in a release is likely to have originated in one of the sources at a site. Attribution usually requires documenting that at least one hazardous substance found in a release at a concentration significantly above background (or directly observed in the release) was produced, stored, deposited, handled, or treated at the site; and at least a portion of the significant increase could have come from a source at the site.

Background Level: The concentration of a hazardous substance that provides a defensible reference point that can be used to evaluate whether or not a release from the site has occurred. The background level should reflect the concentration of the hazardous substance

HIGHLIGHT 5-1
FLOWCHART FOR ESTABLISHING AN OBSERVED RELEASE OR OBSERVED CONTAMINATION



[a] Observed contamination for the soil exposure pathway cannot be established by direct observation.

[b] Observed contamination for the soil exposure pathway can be established if there is no impenetrable cover and the 2 foot limit is considered.

in the medium of concern for the environmental setting on or near a site. Background level does not necessarily represent pre-release conditions, nor conditions in the absence of influence from source(s) at the site. A background level may or may not be less than the detection limit (DL), but if it is greater than the DL, it should account for variability in local concentrations. A background level need not be established by chemical analysis.

Background Sample: A sample used in establishing a background level.

Contract Laboratory Program (CLP): The analytical program developed for CERCLA waste site samples to fulfill the need for legally defensible analytical results supported by a high level of quality assurance and documentation.

Contract-required Detection Limit (CRDL): A term equivalent to the contract-required quantitation limit (CRQL), but used primarily for inorganic substances.

Contract-required Quantitation Limit (CRQL): The substance-specific level that a CLP laboratory must be able to routinely and reliably detect in specific sample matrices. The CRQL is not the lowest detectable level achievable, but rather the level that a CLP laboratory must reliably quantify. The CRQL may or may not be equal to the quantitation limit of a given substance in a given sample. For HRS purposes, the term CRQL also refers to the CRDL.

Detection Limit (DL): The smallest quantity of a hazardous substance that can be distinguished from the normal random "noise" of an analytical instrument or method. For HRS purposes, DL is the method detection limit (MDL) or, for real-time field instruments, the instrument detection limit (IDL) as used in the field.

Method Detection Limit (MDL): The lowest concentration of a hazardous substance that a method can detect reliably in either a sample or blank.

Observed Contamination: Surficial contamination related to a site. It must be established by chemical analysis. Observed contamination is present at sampling locations where analytic evidence indicates that:

- A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (i.e., meets the observed release criteria in HRS Table 2-3).

- The hazardous substance is present at the surface or covered by two feet or less of cover material (e.g., soil).

Observed Release: An observed release is established for the ground water, surface water, or air migration pathway either by chemical analysis or by direct observation. Observed release is not relevant to the HRS soil exposure pathway. The minimum requirements for establishing an observed release by chemical analysis are analytical data demonstrating the presence of a hazardous substance in the medium significantly above background level, and information that some portion of that increase is attributable to the site. The minimum criterion for establishing an observed release by direct observation is evidence that the hazardous substance was placed into or has been seen entering the medium.

Release Sample: A sample taken to determine whether the concentration of a hazardous substance is significantly above its background level in order to determine whether an observed release (or observed contamination) has occurred.

Sample Quantitation Limit (SQL): The quantity of a substance that can be reasonably quantified given the limits of detection for the methods of analysis and sample characteristics that may affect quantitation (e.g., dilution, concentration).

Similar Samples: Samples from the same environmental medium that are identical or similar in every way (e.g. field collection procedure, analytical technique) except the degree to which they are affected by a site.

ESTABLISHING AN OBSERVED RELEASE BY CHEMICAL ANALYSIS

Establishing an observed release (or observed contamination) by chemical analysis generally requires documenting that the concentration of at least one hazardous substance in a release sample is significantly increased above its background level, and that the substance in the release can be attributed to the site. Note that some additional rules apply for observed contamination (see Section 9.1). General guidance for establishing an observed release by chemical analysis is presented below. An observed release is established at most sites by comparing analytical data derived from samples reflective of site-specific background with analytical data derived from site-related samples. Sample data used to establish an observed release should be of known and documented quality. Analytical data may come from the SI or from studies done by other EPA offices, states, other Federal agencies, or PRPs.

CONSIDERATIONS FOR BACKGROUND

All relevant data should be evaluated to determine representativeness of the background samples and attribution. In certain circumstances, background samples are not required to establish an observed release by chemical analysis. Additional guidance used for selecting background samples is provided in Section 5.2. See subsection below, Using Published Data for Background Levels, for a discussion on establishing background levels. The general guidelines below introduce the main concepts.

- Background and release samples must be from the same medium (e.g., soil, water, tissue) and should be as similar as possible. Similar sampling methods should be used to obtain background and release samples. Ideally, background samples also should be outside the influence of contamination from the site, but background levels may be determined from samples which contain measurable levels of contamination.

- Many hazardous substances may be widespread in the environment in the vicinity of a site. Widespread substances may originate naturally, from non-point sources, or from large point sources. The background level for widespread substances should account for local variability. Several background samples may be required to establish variability in background concentrations (see Section 5.2).

SIGNIFICANCE ABOVE BACKGROUND

The concentration in the release sample must be equal to or greater than the release sample SQL. Continue with the steps below only after determining that the release sample is above its SQL. The criteria used for determining significance above background depend on whether the background level is above or below the background DL.

- If the background level is greater than or equal to its DL, the minimum requirement for an observed release is that the concentration in the release sample is at least three times greater than the background level.

- If the background level is below its DL, the minimum requirement for establishing an observed release is that the concentration in the release sample is greater than or equal to the background SQL.

  – If the SQL for the hazardous substance cannot be established and the sample analysis was performed under the CLP, use the CRQL in place of the SQL.

– If the SQL for the hazardous substance cannot be established and the sample analysis was not performed under the CLP, use the DL in place of the SQL.

The considerations detailed in the bullets above are presented in flowchart form in ***Highlight 5-2. Highlight 5-3*** presents several examples of how to decide whether or not significance above background is established.

ATTRIBUTION

Attribution generally involves demonstrating that the hazardous substance used to establish an observed release can be associated with the site, and the site contributed at least in part to the significant increase in the concentration of the hazardous substance. Attribution can be established based on sampling or non-sampling data.

- The following information generally is sufficient to associate the hazardous substance to the site:

  – Manifests, labels, records, oral or written statements, or other information about site operations exist that demonstrates that the hazardous substance was deposited or is present in a source (or somewhere at the site). Note that if confirmed by manifests, labels, or oral or written statements, attribution generally can be established even if the specific source(s) where the substance was deposited cannot be documented.

  – Analytical sampling data that demonstrate the presence of the hazardous substance in a source at a concentration greater than background.

- The data required to attribute a portion of the significant increase in the concentration of the hazardous substance to the site generally depend on whether or not the site being evaluated is located in an area where other sources may have contributed to the significant increase.

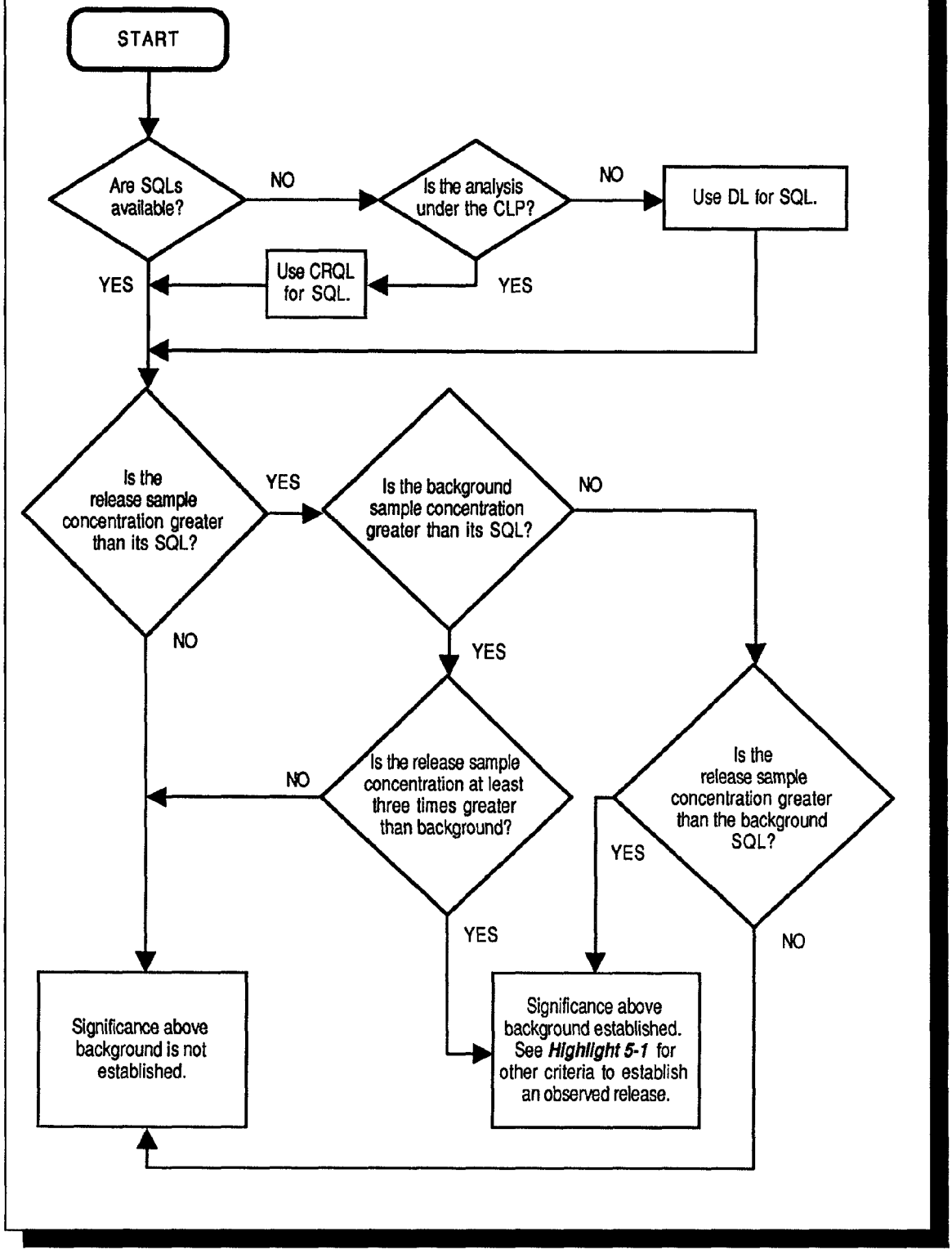
  – When no other nearby sources are likely to have contributed to the release, or when the site-specific background concentration is less than the DL, it generally will be sufficient to document that the hazardous substance is associated with a source at the site that could have released to the environmental medium of concern.

  – When other sources are present in the vicinity of the site being evaluated and may have contributed to the significant increase (e.g., in highly industrialized areas), it generally is necessary to obtain sufficient samples between the site being evaluated and other known potential sources (or between the site and adjacent sites) in order to demonstrate an increase in concentration attributable to the site. Additional information may be required if other sites are known to release substances intermittently, such that "pulses" of hazardous substances are created in environmental media. Types of information that will strengthen such attribution include:

    -- Data on concentration gradients (e.g., established based on samples from multiple wells or a series of samples between the site and the alternative source);

    -- Data on flow gradients or other information about the movement of hazardous substances in the environmental medium of concern; or

HIGHLIGHT 5-2
FLOWCHART FOR DETERMINING SIGNIFICANCE ABOVE BACKGROUND



HIGHLIGHT 5-3
EXAMPLES FOR DECIDING WHETHER SIGNIFICANCE ABOVE BACKGROUND IS ESTABLISHED

Background SQL (ppb)	Background Concertration (ppb)	Sample SQL (ppb)	Sample Concentration (ppb)	Significance Above Background Established?
20	30	50	100	Yes, sample concentration is greater than three times the background concentration
20	30	50	60	No, sample concentration is less than three times the background concentration
20	5[a]	20	16[a]	No, sample concentration is less than the SQL
20	ND[b]	50	55	Yes, sample concentration is greater than both SQLs
50	ND[b]	20	55	Yes, sample concentration is greater than both SQLs
50	ND[b]	20	25	No, sample concentration is less than the background SQL
50	ND[b]	60	55	No, sample concentration is less than the sample SQL

[a] When reported concentrations are less than SQLs, it is likely that data qualifiers would be associated with the concentrations (see ***Highlight 5-4***).

[b] The entry "ND" signifies the substance was not detected (i.e., the background concentration is less than the background SQL).

-- Analytical "fingerprinting" data that establish an association between the site and a unique form of the substance or unique ratios of different substances.

The above general guidelines apply to all HRS pathways and threats. Additional pathway-specific considerations are presented below.

PATHWAY-SPECIFIC CONSIDERATIONS

Ground Water Pathway

- Background and release samples must be from the same aquifer because background levels, water chemistry, and other parameters may vary among aquifers.

- In some cases a contaminated well can serve as its own background (e.g., if similar samples at different points in time establish background levels and levels significantly above background).

- When evaluating a ground water plume with no identified source, background samples are required, but the release need not be attributed to a specific site.

Surface Water Pathway

- Background samples and release samples must be the same type of sample (e.g., aqueous samples must be compared to aqueous samples, sediment samples must be compared to sediment samples).

- For tissue samples, only samples from essentially sessile, benthic organisms (e.g., mussels, oysters) can be used to establish an observed release.

- When evaluating contaminated sediments with no identified source, background samples are required, but no separate attribution is required.

Soil Exposure Pathway

- Observed contamination can be established only when the hazardous substance is present at the surface or covered by two feet or less of cover material (e.g., soil). However, any area covered by a permanent or otherwise maintained, essentially impenetrable material (e.g., asphalt) cannot be considered an area of observed contamination.

- For contaminated soil, areas of observed contamination can be inferred for the area lying between sampling locations at which observed contamination is established unless available information (e.g., topography, site operations, impenetrable cover, drainage patterns) indicates otherwise.

- For sources other than contaminated soil, the entire source is considered an area of observed contamination if observed contamination is established at any point on the source and within two feet of the surface.

Air Pathway

- Indoor air samples cannot be used to establish an observed release.

USING PUBLISHED DATA FOR BACKGROUND LEVELS

At some sites, it may not be possible to collect sample(s) to determine a background level. Certain circumstances may preclude background sampling (or use of available background sampling data) for the site. Several such circumstances are outlined below.

- No appropriate background sampling locations for the site were found. This circumstance generally applies only to the surface water pathway (e.g., a release to an isolated pond or wetland; surface water originates from a spring on the site).

- Resource constraints precluded background sampling.

Under such circumstances, it may be necessary to establish the background level based on published data relevant to the site. Existing data from published reports should be evaluated to determine if background levels can be developed. Documentation should focus on establishing what the concentration of the hazardous substance of concern should be for the medium of concern in the absence of contamination attributable to the site.

The appropriateness of published data for establishing background levels must be determined on a case-by-case basis. No *a priori* set of criteria regarding use of published data can be

established for every hazardous substance and type of site. The guidelines presented below, while helpful in evaluating the appropriateness of such data, are not intended as definitive criteria for accepting or rejecting such data. Published values may not be site-specific enough to be appropriate for determining background levels.

- Potential background levels should be obtained from multiple data sources. Sources of data should include regional and local studies. Ideally, only primary sources should be used. Examples of primary data sources include regional soil lead studies, surveys of sediment contamination in harbors and bays, and national tissue residue surveys such as NOAA's mussel watch program.

- The variability of background concentrations for the substance on a national, regional, and local scale should be described as fully as possible. Variability will depend, in part, on the nature of the hazardous substance. Naturally occurring substances such as heavy metals, for example, are expected to be distributed more widely in the environment than are organic substances used in a limited number of manufacturing practices. Variability will also depend on the local environment. Information on other sources near the site will help determine whether unusually high background concentrations are expected (e.g., soil lead levels are expected to be higher near major highways).

- Regional geology may help determine where higher concentrations of naturally occurring substances are likely (e.g., ore veins, soil types with unusually high metals concentrations).

USING QUALIFIED DATA

For analytical results, particularly those developed within the CLP, various data qualifiers and codes (collectively termed "qualifiers") may be attached to certain data by the laboratory conducting the analysis. Data qualifiers also may be added, modified, or changed during data validation. The qualifiers pertain to QA and QC variations which result in uncertain confidence concerning the identity of the substance being analyzed, its concentration, or both. The QA and QC conditions that result in data qualification must be evaluated with respect to the decision being made (e.g., establishing an observed release) before using the data in HRS scoring. Because non-CLP laboratories may assign codes that differ from those of the CLP, it is important to ascertain the exact meaning of all data qualifiers. See ***Highlight 5-4*** for some considerations that are usually applicable to data generated within CLP.

ESTABLISHING AN OBSERVED RELEASE BY DIRECT OBSERVATION

In contrast to establishing an observed release by chemical analysis, where significance above background and attribution are interrelated, establishing an observed release by direct observation generally only requires information that material containing a hazardous substance attributable to the site was placed into or has been seen entering the medium of concern. Attribution in this case generally involves documenting that the substance in the release is associated with the site, either with non-sampling or sampling data. Pathway-specific considerations are outlined below.

GROUND WATER PATHWAY

- Establishing an observed release by direct observation generally requires information that material containing a hazardous substance has been deposited directly into or otherwise has come to be located (e.g., due to a rising water table) below the top of the aquifer being evaluated.

HIGHLIGHT 5-4
DEFINITIONS AND APPLICATIONS OF COMMON DATA QUALIFIERS

"J" The identity of the hazardous substance is known with certainty, but the reported concentration is considered an estimate. Data may be useable in selected circumstances (see examples below).

"U" The hazardous substance was analyzed for and was not present above the reported concentration. Data may be useable as an upperbound on background concentration.

"R" The identity and concentration of the hazardous substance are uncertain due to exceeded QC limits.
Data generally not useable for either background or release purposes.

For example, suppose a scorer had a background sample of 3J, which is biased high, and a release sample of 10J, which is biased low. The direction of bias Indicates that the accurate background concentration is lower than the reported concentration, and the accurate release concentration is greater than the reported release concentration. Assuming attribution can be established, the data are useable to establish an observed release, because the release concentration (i.e., 10 or more) is more than three times background (i.e., 3 or less).

In a more complex example, suppose a scorer had a background sample of 10J, which was biased high at 30 percent, and a release sample of 40J, which was biased high at 20 percent (i.e., concentration could be as high as 48). Assuming attribution can be established, these data also would be useable to establish an observed release, because the lower bound of the release sample (i.e., 40) is more than three times the upper bound of the background sample (i.e., 13).

SURFACE WATER PATHWAY

- Establishing an observed release by direct observation generally requires information that:
  - Material containing a hazardous substance has been seen entering surface water through migration or direct deposition;
  - A source area has been flooded at a time that a hazardous substance was present in the source, and material containing a hazardous substance was in direct contact with the surface water; or
  - Information documenting adverse affects associated with a release of a hazardous substance to surface water (e.g., a fish kill incident) supports the inference of a release of material containing that hazardous substance from the site to surface water.
- When basing an observed release on inference of a release by demonstrated adverse effects, it generally is necessary to provide a rationale for inferring the release from the site, to document that the substance was present on the site prior to or at the time the adverse effects occurred, and to document that the adverse effects were likely caused by the substance.
- When the source area that has been flooded is contaminated soil, it is necessary to demonstrate that the hazardous substance was present at a concentration significantly above background level in order to document an observed release.

SOIL EXPOSURE PATHWAY

- Observed contamination in the soil exposure pathway cannot be established by direct observation.

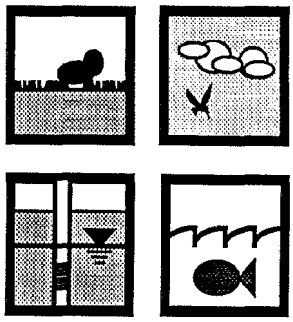
AIR PATHWAY

- Establishing an observed release by direct observation generally requires information that:
  - Material containing a hazardous substance has been seen entering the atmosphere directly (e.g., particulate material blowing off a pile);
  - Information supports the inference of a release from the site to the atmosphere of material that contains at least one hazardous substance; or
  - Information documenting adverse effects associated with the release of a hazardous substance to air (e.g., human health effects) supports the inference of a release of material containing that hazardous substance from the site to air.
- When basing an observed release on inference of a release by demonstrated adverse effects, it generally is necessary to provide a rationale for inferring the release from the site, to document that the substance was present on the site prior to or at the time the adverse effects occurred, and to document that the adverse effects were likely caused by the substance.
- If the source used to establish an observed release is contaminated soil, it is necessary to demonstrate that the hazardous substance was present at a concentration significantly above background level to document an observed release.

TIPS AND REMINDERS

- Establishing an observed release by direct observation generally requires the following information: (1) material containing a hazardous substance was placed into or has been seen entering the medium of concern, and (2) the substance in the release is associated with the site. If the source is contaminated soil, the concentration of the hazardous substance in the contaminated soil must be significantly above background and some portion of the increase must be attributable to the site.
- Establishing an observed release by chemical analysis generally requires the following information: (1) the concentration of at least one hazardous substance in a release sample is significantly increased above the background level, (2) the substance in the release is associated with the site, and (3) the site contributed at least in part to the significant increase.
- Background level need not be established by chemical analysis.
- The difficulties in attributing an increase in concentration to a site can be avoided if an observed release by direct observation can be established.

SECTION 5.2
SELECTING APPROPRIATE BACKGROUND SAMPLES



A background level for a site provides a reference point by which to evaluate whether or not a release of a hazardous substance from the site has occurred. Determining background level is necessary to establish an observed release (or observed contamination) by chemical analysis. This section provides guidance on selecting appropriate samples for determining background level for a site. The application of background levels in establishing an observed release (or observed contamination) by chemical analysis is discussed in Section 5.1 of this document.

When chemical analysis is used to determine background levels, the background and release samples must be from the same medium (e.g., soil, water, tissue) and should be as similar as possible except for potential influence from the site. Similar sampling methods should be used to obtain background and release samples. Ideally, background samples should be outside the influence of contamination from the site, but background levels may be determined from samples that contain measurable levels of contamination. Background levels also do not need to represent pre-release conditions at the site.

RELEVANT HRS SECTIONS

Section 2.3	Likelihood of release
Section 3.1.1	Observed release (ground water)
Section 4.1.2.1.1	Observed release (surface water)
Section 5.0.1	General considerations (soil exposure)
Section 6.1.1	Observed release (air)

DEFINITIONS

Background Level: The concentration of a hazardous substance that provides a defensible reference point that can be used to evaluate whether or not a release from the site has occurred. The background level should reflect the concentration of the hazardous substance in the medium of concern for the environmental setting on or near a site. Background level does not necessarily represent pre-release conditions, nor conditions in the absence of influence from source(s) at the site. A background level may or may not be less than the DL, but if it is greater than the DL, it should account for variability in local concentrations. A background level need not be established by chemical analysis.

Background Sample: A sample used in establishing a background level.

Release Sample: A sample taken to determine whether the concentration of a hazardous substance is significantly above its background level in order to determine whether an observed release (or observed contamination) has occurred.

Similar Samples: Samples from the same environmental medium that are identical or similar in every way (e.g., field collection procedure, analytical technique) except the degree to which they are affected by a site.

DATA REQUIREMENTS

The minimum data requirements for establishing background levels by chemical analysis include the actual analytical data from the background sample(s) and sufficient other information to establish similarity between background and release samples. Analytical data may be obtained from one or more background sample(s).

NUMBER OF SAMPLES FOR ESTABLISHING BACKGROUND LEVELS BY CHEMICAL ANALYSIS

Where background is established by chemical analysis, a single sample may provide a defensible background level. However, when the hazardous substances being considered are widespread in the environment (e.g., pesticides in an agricultural area, naturally occurring trace metals) and/or may have come from other nearby sites, one sample generally will not be sufficient. At such sites, attribution also may be difficult (see Section 5.1). Factors influencing the number of samples used to establish background levels by chemical analysis include:

- Physical complexity of the site (e.g., size, number of source types);
- Physical complexity of migration routes (e.g., number of watersheds, number of overland segments in each hazardous substance migration path);
- Temporal complexity of site data (e.g., time periods over which sampling and other data were collected);
- Meteorological conditions under which samples were collected;
- Number of hazardous substances present at the site, their expected concentrations in sources and releases, and the degree to which they are widespread in the vicinity of the site;
- Number and physical/chemical complexity of environmental media being sampled (e.g., number and interconnection of aquifers, heterogeneity of soils and sediments, number and type of water bodies within watershed);
- Type of samples (e.g., filtered or unfiltered); and
- Other potential sources in the vicinity of the site.

At some sites, multiple background samples appropriate for a particular environmental medium will exhibit different concentrations for the same hazardous substance. In this situation, using the sample with the highest concentration is always defensible in a legal sense (i.e., the background level based on available samples could not be higher than the value selected), but it may not always be appropriate. Generally, it is best to decide on a case-by-case basis whether to use the highest, lowest, or a measure of central tendency of the samples to establish background.

ESTABLISHING SIMILARITY BETWEEN BACKGROUND AND RELEASE SAMPLES

Analytical data from background samples is necessary but may not be sufficient to establish background levels by chemical analysis. Additional information related to the site and sampling procedures is often desirable to establish similarity between the background and release samples. Examples of things to consider in establishing similarity may include:

- Type of samples (e.g., soil, sediment, air);
- Time and location at which samples were collected;
- Physical conditions under which samples were collected (e.g., meteorological conditions, season);
- Sampling, handling, and analytical chemistry procedures used; and
- Environmental setting for each sample (e.g., topography, land use in the vicinity of the sampling locations, streamflow).

DATA EVALUATION GUIDELINES

Temporal and spatial variations in measured concentrations often make it difficult to define background. Large differences in analytical results may result from differences that are independent of site-related contamination (e.g., differences in the manner in which samples were collected, differences in the physical or chemical conditions under which the samples were collected). This section provides guidance for selecting background samples that will yield the most defensible background levels. General considerations are followed by pathway-specific considerations.

GENERAL CONSIDERATIONS

- In most cases, samples will be designated as background at the time of an SI. In some cases, however, it may be necessary to re-evaluate which samples are background and release after the data have been collected (e.g., when analytical data or additional site information suggest a different pattern of contamination than originally expected).
- Sampling and analysis methods should be the same for background and release samples.
- Background samples do not have to be completely outside the influence of the site. This may be particularly applicable in areas where the presence of other potential sources and/or the complexity of the nearby environment make it difficult to select a background sampling location that is not influenced by the site.

GROUND WATER PATHWAY

Data evaluation guidelines for the ground water pathway are presented below. General guidelines are presented first, followed by guidelines specific to the following situations: the background well and release well are in the same aquifer; there is no background well in the aquifer in which the release well is located; and the release well serves as its own background well.

General Guidelines

- An understanding and description of aquifers and their boundaries are necessary for identifying background samples. Information must be sufficient to identify the types and boundaries of geologic materials within the TDL for the site. Minimum information includes types of bedrock, soil, or other non-consolidated material, and their lateral and vertical boundaries; types of surficial deposits and their boundaries (i.e., thicknesses and lateral extents); and locations and screened depths of release and background wells. Guidance on determining aquifers and aquifer boundaries is presented in Section 7.1.

- When a connection has been established between two individual aquifers, the background sample must be taken from the same aquifer as the release sample (e.g., a background sample taken from a bedrock aquifer cannot be compared to a release sample taken from an overlying alluvial aquifer, even if a hydrologic connection has been documented between the two aquifers and they are being considered a single hydrologic unit for purposes of HRS scoring). Different aquifers may have very different background levels as well as other important differences in water chemistry.

- Information on ground water flow gradients in the area is not required and may not be known completely at the time of the SI. Depending on site conditions, background wells may be upgradient, side-gradient, or downgradient from sources. In complex situations, with multiple sources and aquifers, selecting or installing wells for background samples will require considerable knowledge of aquifers, aquifer boundaries, and aquifer interconnections.

Background Well and Release Well In Same Aquifer

At some sites, one or more potential background wells already exist in the aquifer(s) of concern (i.e., these wells did not need to be installed during the SI). Such a situation generally will make it easier to obtain background samples. However, existing wells may not be suitable for background samples, even if they are not influenced by sources at the site. ***Highlights 5-5, 5-6***, and ***5-7*** provide illustrations of appropriate background wells for the ground water pathway. Note that these illustrations are highly idealized and are not meant to reflect expected site-specific conditions.

- In general, background and release samples should be from approximately the same depths in an aquifer, although different depths may be appropriate under certain circumstances. Factors to consider include aquifer structure, the nature of the hazardous substances, and other possible sources, including natural sources. Ground water tends not to be well mixed, and water quality can vary significantly in the vertical plane within an aquifer. This is particularly true when substances that have a tendency to sink or float in the aquifer are present (i.e., dense non-aqueous phase liquids (DNAPLs) and light non-aqueous phase liquids (LNAPLs)). Depth should be determined relative to a fixed reference point (e.g., mean sea level) rather than the ground surface to eliminate apparent differences caused by surface topography.

- If the background sample well is screened, the well screen interval must be in the same aquifer as the release sample well.

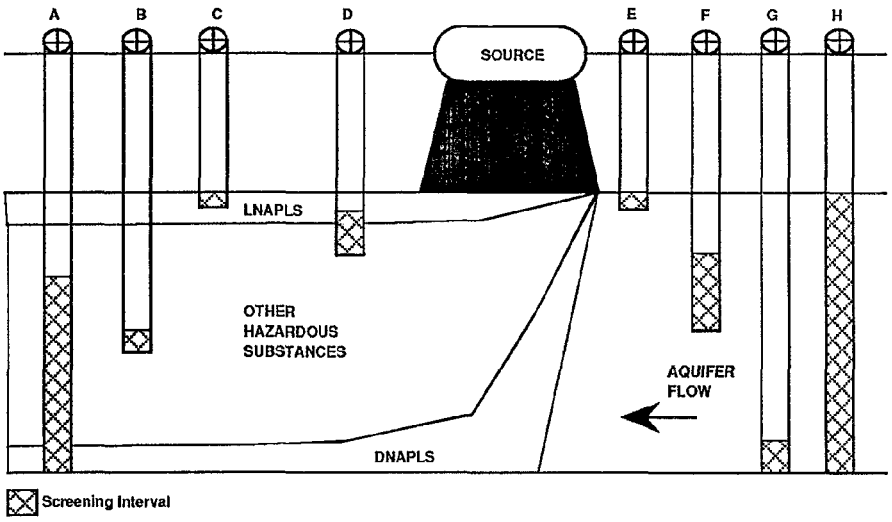
- A well screened over two or more distinct aquifers cannot be used to establish background or release levels of hazardous substances.

- Take particular care in areas that are hydrogeologically complex. In glaciated terrain, for example, water may occur within sand lenses of limited areal extent, and surrounding soil with a substantial clay component could serve to isolate these lenses. Thus, each sand lens may be, in effect, a small, independent aquifer, making it difficult to establish background. In such areas, geologic cross sections may be necessary to understand the underlying aquifer system.

No Background Well In Release Well Aquifer

At some sites, no potential background wells exist in the aquifer(s) of concern prior to the SI. At these sites, background levels may be determined only in two ways: by installing monitoring wells at appropriate background locations, or based on appropriate published concentration data. Data from monitoring wells generally are preferred over data from the literature. Guidance for using published concentration data to establish background levels is presented in Section 5.1.

HIGHLIGHT 5-5
ILLUSTRATION OF APPROPRIATE BACKGROUND SAMPLES: GROUND WATER PATHWAY — SINGLE AQUIFER

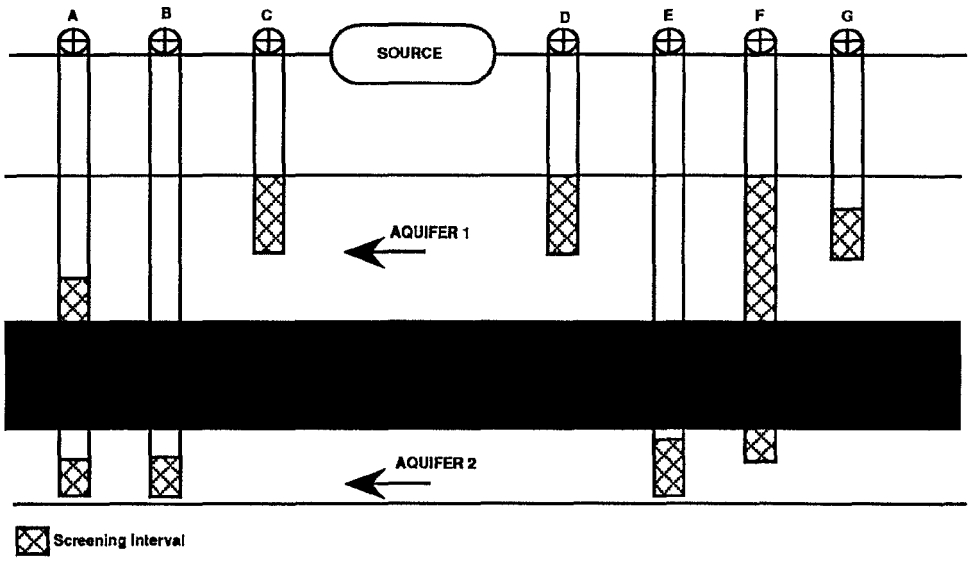


Illustrated in this idealized drawing is a source releasing LNAPLs, DNAPLs, and other hazardous substances to a single aquifer. Assume that the eight wells have a similar development history. The appropriateness of each well for release and background samples is given below:

Type of Hazardous Substance	Release Samples				Background Samples			
	A	B	C	D	E	F	G	H
LNAPLs	N/A	N/A	Yes	Yes	Yes	No	No	Yes
Others	Yes	Yes	N/A	Yes	No	Yes	No	Yes
DNAPLs	Yes	N/A	N/A	N/A	No	No	Yes	Yes

- For LNAPLs, E and H are appropriate background wells and C and D are appropriate release wells because their screening intervals are at the top of the aquifer (where LNAPLs are likely to occur).
- For DNAPLs, G and H are appropriate background wells and A is the only appropriate release well because their screening intervals are at the bottom of the aquifer (where DNAPLs are likely to occur).
- For other hazardous substances, F and H are appropriate background wells and A, B, and D are appropriate release wells because their screening intervals are in the middle of the aquifer (where these substances are likely to occur).

HIGHLIGHT 5-6
ILLUSTRATION OF APPROPRIATE BACKGROUND SAMPLES: GROUND WATER PATHWAY — MULTIPLE AQUIFERS

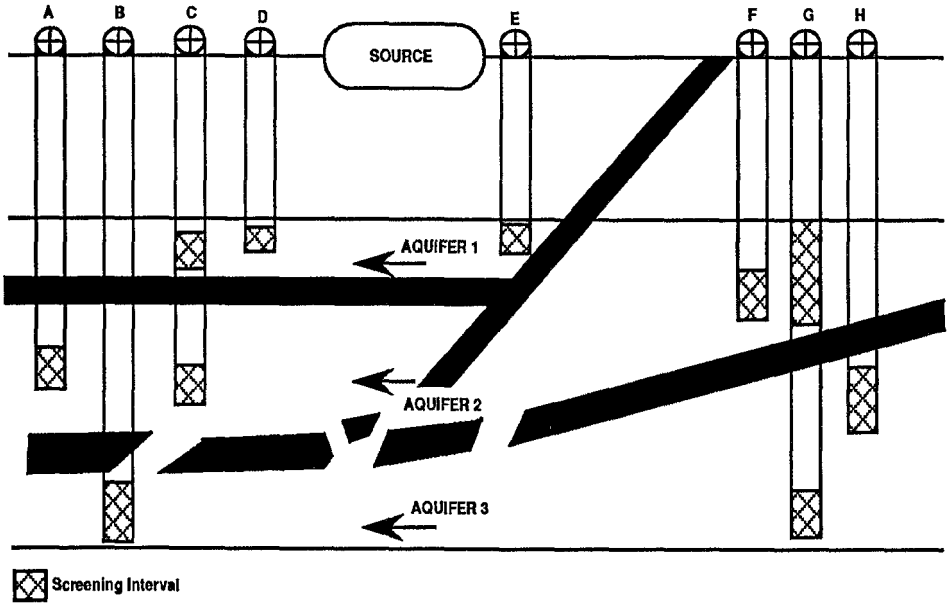


Illustrated in this idealized drawing is a source releasing hazardous substances to two aquifers that are not interconnected within 2 miles of sources at the site. Assume that the seven wells have a similar development history. The appropriateness of each well for release and background samples is given below:

Aquifer	Release Samples			Background Samples			
	A	B	C	D	E	F	G
Aquifer 1	No	No	Yes	Yes	No	No	Yes
Aquifer 2	No	Yes	No	No	Yes	No	No

- For Aquifer 1, D and G are appropriate background wells and C is an appropriate release well.
- For Aquifer 2, E is an appropriate background well and B is an appropriate release well. A is not an appropriate release well and F is not an appropriate background well because both wells are screened in both aquifers.

HIGHLIGHT 5-7
ILLUSTRATION OF APPROPRIATE BACKGROUND SAMPLES: GROUND WATER PATHWAY – INTERCONNECTED AQUIFERS



Illustrated in this idealized drawing is a source releasing hazardous substances to three aquifers, two of which are interconnected within 2 miles of sources at the site. Assume that the eight wells have a similar development history. The appropriateness of each well for release and background samples is given below:

Aquifer	Release Samples				Background Samples			
	A	B	C	D	E	F	G	H
Aquifer 1	No	No	No	Yes	Yes	No	No	No
Aquifer 2	Yes	No	No	No	No	Yes	No	No
Aquifer 3	No	Yes	No	No	No	No	No	Yes

- For Aquifer 1, E is the only appropriate background well and D is the only appropriate release well.
- For Aquifer 2, F is the only appropriate background well and A is the only appropriate release well. Although Aquifers 2 and 3 are interconnected, H is not an appropriate background well for Aquifer 2 because it is screened in Aquifer 3.
- For Aquifer 3, H is the only appropriate background well and B is the only appropriate release well.
- Well G cannot serve as a background well because it is screened in both Aquifer 2 and Aquifer 3. Well C cannot serve as a release well because it is screened in both Aquifer 2 and Aquifer 3.

Release Well Serves as its Own Background

Under some circumstances a single well, over time, may provide both background and release samples. For example, where a regular water quality monitoring program is in effect (e.g., at municipal wells), a time series of monitoring data may document encroachment of a hazardous substance plume. Data must be available from a sufficient period of record, so that a trend in increasing concentrations can be demonstrated clearly.

SURFACE WATER PATHWAY

Data evaluation guidelines for the surface water pathway are presented below. General guidelines are presented first, followed by guidelines specific to particular types of surface water bodies (i.e., streams and rivers; lakes, Great Lakes, and other large water bodies; and tidally influenced areas) and particular types of samples (i.e., aqueous, sediment, and tissue). ***Highlight 5-8*** provides an idealized illustration of appropriate background sampling locations for the surface water pathway.

General Guidelines

- An observed release by chemical analysis can be established in the surface water pathway using aqueous samples, sediment samples, and/or tissue samples from essentially sessile benthic organisms. Background and release samples must be of the same type (e.g., aqueous samples must be compared to aqueous samples, sediment to sediment).

- Chemical and physical properties of surface water and sediments may vary substantially within a small area. Stratification of lakes, lack of mixing in slowly moving rivers, and mixing effects induced by tributaries may affect the appropriateness of a given sampling location for establishing background levels. Environmental conditions at both the background and release sample locations should be similar.

Non-tidal Streams and Rivers

- Background samples should be collected upstream from the potentially contaminated area. In the simplest case (i.e., one PPE and one main channel), one background sample may be sufficient. In cases where there is significant branching or tributary input upstream of the PPE, more than one background sample may be appropriate.

- If there are multiple PPEs, background samples may be appropriate for each PPE, particularly if the hazardous substances for each PPE are different and significant branching or tributary input occurs between PPEs.

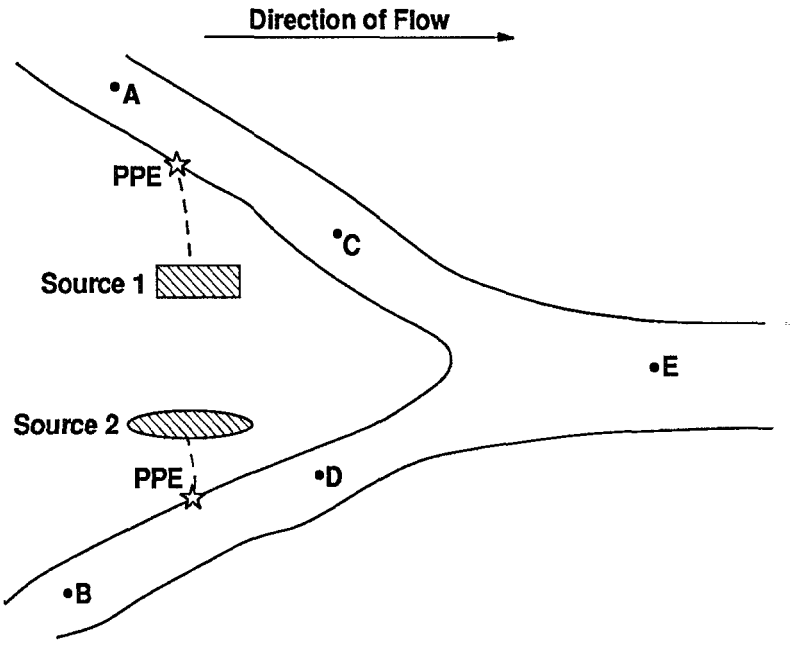
- Where possible, background and release samples should be collected from the same general part of the surface water body (e.g., a background sample taken near one bank generally should not be compared with a release sample taken from the center of the main channel).

Ponds and Other Small, Isolated Water Bodies

In ponds and other small, isolated water bodies, it may not be possible to collect background and release samples from the same water body (e.g., the entire pond may be influenced by the site). In that case, background can be established as follows.

- Samples of water flowing into the pond may provide background levels if there is a clear inflow and this is not influenced by the site.

HIGHLIGHT 5-8
ILLUSTRATION OF APPROPRIATE BACKGROUND SAMPLES: SURFACE WATER PATHWAY — STREAMS AND RIVERS



Illustrated in this idealized drawing is a site releasing hazardous substances from two sources to two branches of a river. Assume that the five samples are similar (e.g., they are all sediment samples collected from similar substrates at similar times and were handled and analyzed in an identical manner). The appropriate background sample for each release sample is given below:

Release Sample	Appropriate Background Sample(s)	
	A	B
Sample C	Yes	No
Sample D	No	Yes
Sample E	Yes	Yes

- For Release Sample C, A is the only appropriate background sample because any increased hazardous substance concentrations could be attributed to Source 1.
- For Release Sample D, B is the only appropriate background sample because any increased hazardous substance concentrations could be attributed to Source 2.
- For Release Sample E, both A and B are appropriate background samples because contamination could be flowing down either or both branches upstream of Sample E.

- Samples from an analogous water body outside of the area influenced by the site (e,g., a nearby pond of similar size and type) may provide background levels.

- Background levels may be established based on literature values without having to take samples (see Section 5.1).

Lakes, Great Lakes, and Other Large Water Bodies

- In smaller lakes, samples at the point where surface water enters the take generally will provide appropriate background levels. If there is no obvious point of entry, it generally is best to use samples as far as possible from the PPE(s) to establish background levels. However, the presence of springs, other potential sources, and points of flow out of the lake may influence selection of background locations.

- If other potential sources are near the site, background samples should be collected between the PPE for the site and the PPE for other potential sources. Ideally, background samples should also be out of the zone of influence of the other potential sources.

- In large water bodies, background samples should be collected as far from the PPE as possible, except when other potential sources, points of flow into the lake, or points of flow out of the lake are present in between.

Tidal Areas

- In tidal water bodies, background samples ideally should be collected beyond the farthest upstream point at which substances from the site might be transported by the tide. If it is difficult to determine exactly how far upstream substances might be transported, it may be appropriate to collect background samples above the "head of the tide" (i.e., the most upstream point at which tidal cycles are present), as long as it isn't too far upstream to be unrepresentative of background. In some cases, a series of samples successively farther upstream may be required.

- In tidally influenced areas, it is especially important to be aware of attribution problems that might be presented by non-site related sources of contamination either upstream or downstream from the PPE. In general, attribution will be more difficult as distance from the PPE increases.

- For aqueous samples, sample collection times in relation to tidal cycles should be considered. Hazardous substance transport upstream will be greatest during a rising tide and lowest during a failing tide. Background aqueous samples are most likely to have the least site-related contamination toward the end of the failing tide, when downstream flow is expected to exert maximum flushing effect. Site-related concentrations in the background sample are likely to be higher toward the end of the rising tide, when contaminated water is carried upstream to the maximum extent.

Sediment Samples

- Sediment type should be similar in background and release samples. Fine clay particles are more likely to adsorb hazardous substances such as metals and hydrophobic organic compounds than are larger particles or particles with a predominately sandy matrix. Different sediment types tend to accumulate in different areas of a stream or lake. Fine sediments will predominate in quiescent zones, whereas sandy sediments, with fewer fine particles, will be found in more turbulent areas. Visual documentation of sediment type similarity is generally sufficient.

Tissue Samples

- The only tissue samples that may be used to establish an observed release are those from essentially sessile, benthic organisms. Such organisms do not need to be human food chain species. This ensures that any contamination found in the tissue can be attributed to the immediate area in which the organism was collected. Benthic organisms are generally those which spend most of their lives on the bottom of a water body, and sessile organisms are those which are relatively immobile. Examples of essentially sessile, benthic organisms include sponges, oysters, and mussels.

- Concentrations of hazardous substances in tissue samples may vary among different species, different individuals within a species, and different organs and tissues within an individual organism. At a minimum, background and release tissue samples must be of the same species. Ideally, background and release samples should be from organisms of similar age, if age can be determined. If variability among individuals is high, multiple background and release samples may be appropriate.

SOIL EXPOSURE PATHWAY

- Soil is a heterogeneous material that may vary substantially in texture and other physical and chemical properties. Background and release samples should be collected in areas with similar soil characteristics.

- Site setting and operational history should be considered in selecting background samples. Information about site operations may indicate which areas were subject to a particular type of contamination and which areas may serve as background for the contaminated areas. Land features might prevent the migration of liquids to certain portions of the site. Other contaminated sites nearby may affect the appropriateness of a particular location for background samples.

- Some sites may be located in or near areas that have been filled, and the fill soils may have come from different locations. If possible, background samples should be from undisturbed areas (e.g., those with mature vegetation).

- Soil within a dry drainage ditch or swale is subject to many outside influences and generally should not be used for determining background levels. An exception might be if the contaminated soil source is in the same swale or drainage ditch.

AIR PATHWAY

Wind direction is of paramount importance in determining background levels for air samples. A background air sample will ideally be collected upwind from the area of contamination. However, cross-wind samples may also be acceptable for background conditions and should be used if potential sources of similar contamination are located cross-wind. Consideration must be given to the entire time period over which a sample was collected. Data on the predominant wind direction in an area are insufficient to determine background; wind direction must be established during the sampling period.

- During any sampling event it is likely that changes in wind speed and direction will occur. A wind rose, based upon continuous data collected during the entire period of site sampling, may be helpful for selecting background.

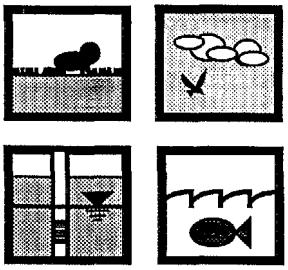
- Background and release samples should be from approximately the same heights above the ground surface. Samples do not need to be collected from the "breathing zone." Samples from very low heights should be evaluated carefully because field activities, particularly soil disturbance, may introduce contamination.

- Background and release samples generally should be collected simultaneously.
- Indoor air samples cannot be used to establish background levels (or to establish an observed release).

TIPS AND REMINDERS

- Large differences in the physical or chemical characteristics of background and release samples may indicate artifacts introduced during the sampling process. For example, a high concentration of suspended solids in a ground water sample may indicate insufficient purging of the well prior to sampling and/or substantial disturbance to the well during sampling.
- Ground water wells from which background and release samples are obtained must be completed in the same aquifer and should generally be at approximately the same relative depth in the aquifer.
- Background and release samples should be collected within the same time frame, as appropriate for the pathway.
- Background and release sediment (or soil) samples should be of similar type.
- Tidal effects should be considered when establishing background sampling locations in surface water.
- Knowledge of site operations can often provide clues to appropriate locations for background soil samples.

SECTION 5.3
TRANSFORMATION PRODUCTS



A hazardous substance exposed to other substances or to the environment is susceptible to transformation by physical, chemical, and biological processes. The products of these reactions are termed transformation products. Substances found in the environment (i.e., the transformation products) may be different than those found or otherwise documented in sources at the site (i.e., the parent substances). This section provides guidance for establishing an observed release (or observed contamination) based on transformation products.

RELEVANT HRS SECTIONS

Section 2.3	Likelihood of release
Section 3.1.1	Observed release (ground water)
Section 4.1.2.1.1	Observed release (surface water)
Section 5.0.1	General considerations (soil exposure)
Section 6.1.1	Observed release (air)

DEFINITIONS

Transformation Product: The substance(s) resulting from the transformation of a hazardous substance in the environment by physical, chemical, and/or biological processes. The original hazardous substance is referred to as the parent substance. When a transformation product is a simpler, less complex substance than the parent substance, it is referred to as a degradation product. When a more complex substance is produced, the product is often referred to as a formation product.

GENERAL REQUIREMENTS

Most transformation products of environmental concern at waste sites are degradation products. Examples of physical degradation processes include spontaneous decay of radioactive substances (e.g., uranium to radium) and dechlorination of aromatic hydrocarbons due to photodegradation (e.g., heptachlorobiphenyl to hexachlorobiphenyl). Examples of chemical degradation processes include oxidation/reduction reaction of chromium VI to chromium III, acid/base reaction of sulfuric acid to sulfate salts, and dissolving of metals due to ground water acidification by landfill leachate (e.g., lead solid to lead ion under low pH conditions). Examples of biological degradation processes include transformation of trichloroethane to dichloroethane; hydroxylation of benzenes to phenolics by aerobic microorganisms (dichlorobenzene to dichlorophenol); and dehalogenation (i.e., removal of a halide) of aromatic pesticides by anaerobic microorganisms (e.g., pentachlorophenol to tetrachlorophenol). ***Highlight 5-9*** provides some examples of common degradation products and their parent substances.

HIGHLIGHT 5-9
TYPICAL DEGRADION PRODUCTS

Parent Substance(s)	Typical Degradation Product(s)
Chloromethanes (e.g., carbon tetrachioride)	Other chloromethanes with fewer chlorines; formaldehyde; chloroform
Chloroethanes (e.g., tetrachloroethane, trichloroethanes (1,1,1 or 1,1,2), dichloroethanes, chloroethanes)	Other chloroethanes with fewer chlorines; chloroethanols; ethanol; chloroethenes
Chloroethenes (e.g., tetrachloroethene, trichloroethene, dichloroethenes vinyl chloride)	Other chloroethenes with fewer chlorines; chloroethanols; chloroethanes
Chlorobenzenes and chlorophenols, hexachlorobenzene, pentachlorophenols	Other chlorobenzenes and chlorophenols with fewer chlorines; chlorocatachols; chlorobenzoic acids; phenols
Polychlorinated biphenyls (PCBs)	Other PCBs with fewer chlorines; chlorobenzenes
DDT	DDE, DDD
Disulfoton	Carbon disulfide
2,4-Dichlorophenoxyacetic acid (2,4-D)	2,4-Dichlorophenol; 3,5-Dichlorocatechol; 2,4-Dichloromuconic acid
Aldrin	Dieldrin

The same requirements for establishing an observed release by chemical analysis that apply to hazardous substances in general apply to transformation products (see Section 5.1). Transformation products must be hazardous substances in order to be used to establish an observed release (or observed contamination). Also, an observed release based on transformation products cannot be established by direct observation.

ESTABLISHING AN OBSERVED RELEASE (OR OBSERVED CONTAMINATION) FOR TRANSFORMATION PRODUCTS

The steps outlined below describe how to establish an observed release (or observed contamination) for transformation products.

(1) **Document the presence of the transformation product(s) in the release sample at levels significantly greater than background.** Analytical data used to demonstrate the presence of a transformation product must meet the same significance, attribution, and QA/QC requirements as for any other hazardous substance (see Section 5.1). The transformation products should be considered to be present in the media they have been found in, but this does not mean they necessarily are available to other pathways. For example, a transformation product detected in ground water is not necessarily available to the air pathway. Any hazardous substance documented to be in a source is considered available to all pathways for which the source has a non-zero containment factor value.

(2) **Attribute the parent substance to the site.** Establishing attribution of the parent substance to the site usually involves documenting that the parent substance was deposited or is present in a source, or that the parent substance was produced, stored, deposited, or treated at the site and/or originated in or resulted from activities at the site.

The following types of information may be used to establish attribution of a parent substance to a site (in order of preference).

- The most complete information is chemical analysis of samples from at least one source in the site and documentation that the substance was placed in the source. If the source is contaminated soil or contains soil used as cover or fill material, it generally also will be necessary to document that the concentration of the substance in the source is significantly above background.

- If the above information cannot be obtained, documentation by chemical analysis that the parent substance is in a source can be used alone if the source does not contain soil or if the substance is not a naturally occurring substance.

- If analytical data are not available, records or manifests indicating the parent material was placed in a source are preferred. Documentation that the parent substance was used, stored, or handled at the site is also acceptable.

- In some situations, information indicating that a parent substance was most likely present at a site because of the nature of the site activity may also be considered adequate attribution (e.g., carbon tetrachloride or tetrachloroethene at a dry cleaning facility).

(3) **Attribute the transformation product to the site.** Attributing the transformation product to the site generally involves documenting that the hazardous substance detected in the receiving medium is the transformation product of a parent substance attributable to that site. Establishing attribution of a transformation product to the site usually involves documenting the following.

- The substance detected in a medium is a transformation product of the parent material, as shown by:

  — Site-specific studies on the transformation process by qualified research organizations (e.g., universities, EPA research laboratories);

  — EPA technical reports discussing the transformation of the parent substance, such as from the Office of Research and Development, the Risk Reduction Engineering Laboratory (RREL), and/or the Center for Environmental Research Information (CERI);

  — Information in data bases containing EPA-reviewed information (e.g., the computerized RREL "Treatability Data Base");

  — Articles from peer reviewed journals; or

  — Textbooks on soil and environmental microbiology, biotechnology, and biotreatment processes and their effectiveness.

- A significant increase of the transformation product relative to its background for the site has occurred.

- At least some portion of the significant increase of the transformation product above background can be attributed to the site.

Information that would further support attribution (but would not be sufficient by itself) includes:

- Conditions at the site are such that it is possible that the parent material has transformed into these substances, or, at minimum, that the conditions at the site do not prevent the transformation from occurring (e.g., the transformation requires oxidizing conditions and these exist at the site); and

- There is a non-zero containment factor value for at least one source at the site containing the parent material.